

GEOBROWSER

Arranging the stuff of everything

To honour the achievement by the Russian chemist, Dmitri Mendeleev, the UN declared 2019 as the International Year of the Periodic Table. An article by Western Oregon University (1997) notes that although some 63 elements had been discovered over the previous 200 years it was Mendeleev who, in 1869, narrowly beat the German Lothar Meyer to publish a table arranging them into the rows and columns we are familiar with today. Mendeleev's table was the first to show that the elements followed regular and predictable patterns over an entire network of vertical, horizontal and diagonal relationships.

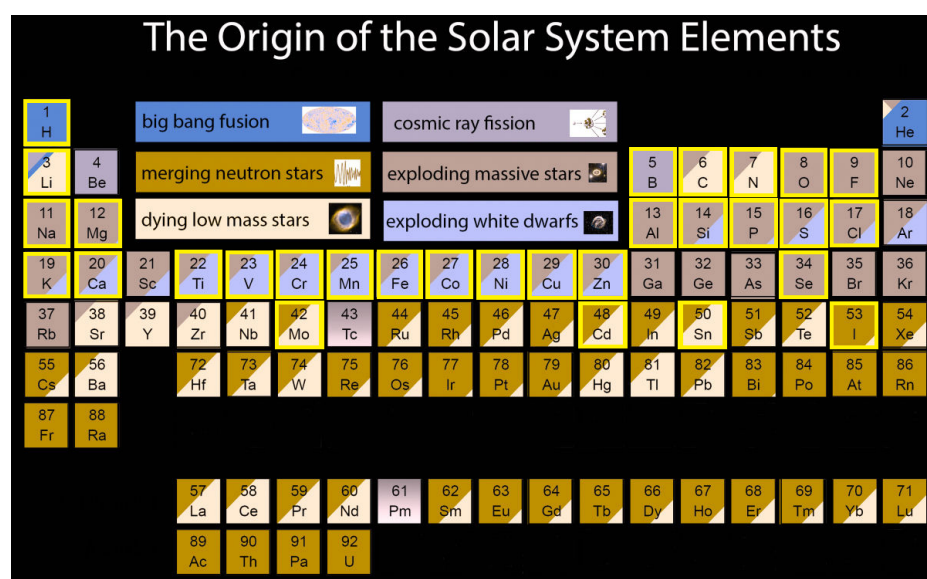
Such was Mendeleev's subsequent fame that he was nominated for a Nobel Prize in 1906, a year before his death from flu at the age of 72. He missed out by a single vote, probably because he was not alone in recognising that some sort of table was required. He was nevertheless lauded globally and rewarded in his own country, where the Tsar overruled religious authorities that had brought a (technical) charge of bigamy against him. Mendeleev's major contributions to chemistry also involved applications to geological issues such as mineral recovery and oil refining.

Mendeleev's table demonstrated that there are recurring variations in element properties with increasing atomic number, and the sciences of cosmology and astrophysics have revealed one far-reaching implication of this. As shown by Jennifer Johnson's modified table, most of the elements making up our planet and all living things upon it, including ourselves, can only have evolved during the extreme conditions of pressure and temperature prevailing during the cataclysmic end-stages of a star's life. In these nuclear furnaces, protons and neutrons are fired into atomic nuclei, resulting in the increased atomic

numbers that signify the progressive creation of newer and heavier elements. Perhaps Mendeleev had an inkling of this when he wrote that: *It is the function of science to discover the existence of a general reign of order in nature and to find the causes governing this order. And this refers in equal measure to the relations of man – social and political – and to the entire universe as a whole.* (Cited from Goodreads Inc, 2019).

Deep-sea mining challenges

Mineral exploitation has always required substantial financial investment, but it is probably fair to say that success as defined in today's global commodities market has required manifold increases in the scale of projects, and therefore the risks involved. Deep-sea mineral extraction is a new frontier that is proving to be a potentially hazardous undertaking for investors, as exemplified by the experience of Nautilus Minerals. In the *Mercian* for 2018 (pp 182–7) we reported that intensive exploration of a volcanogenic polymetallic sulphide deposit in the Bismarck Sea had proved deposits of copper, silver and gold promising enough to prompt the construction of an ore-carrying mother ship and some impressive deep-sea robotic extraction equipment. Operations were scheduled to commence in 2019, although the Canadian company had issued a rather ominous press release (2018-11) that the finance to do this was not yet in place. In the event, essential bridging loans could not be repaid and funding for the support vessel dried up midway through its construction in China. It has now apparently been sold-on to an Indian conglomerate (MDL Energy) to be repurposed for harvesting polymetallic nodules, a technologically less demanding exercise. In April this year the *Deep Sea Mining Observer* reported that Nautilus was delisted from the Toronto stock exchange amid resignations of many directors and the Company's CEO. Although it is always possible that other companies may take up the licences, the whole project – and indeed Nautilus Minerals – look to be dead in the water.

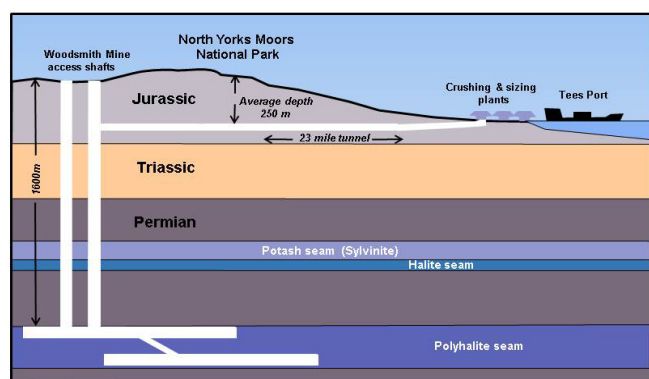


The modern Periodic Table modified by Jennifer Johnson and colleagues (Ohio State University, 2017) to show how those elements occurring naturally in our Solar System have originated by processes basically involving nuclear fusion (nucleosynthesis); for example in exploding, dying or merging stars. Using various other sources we have highlighted the elements making up the human body as yellow square-surrounds: they include those regarded as non-essential but physiologically beneficial.

National Park new mineral bonanza?

The North York Moors National Park conceals beneath it Britain's largest active mining complex, and also its deepest at just over 1 km. Opened in 1968 and now with over 1000 km of tunnels and roadways, the Boulby mine has exploited a complex system of seams containing rock salt and potash formed by evaporative processes in the Permian Zechstein basin. Since 2018, however, the entire production has been switched to the mining of a lower seam with an abundance of polyhalite (*Kelley Price, Teesside Live website, May 2019*), a multi-mineral salt comprised of calcium, magnesium and potassium sulphates. Branded as 'Polysulphate', its properties as a natural agricultural fertilizer are such that after trials leading to world-wide approval it has been acclaimed as 'ground-breaking', although certain more cautious commentators prefer to regard it as a 'niche product' (*Reuters Business News website, May 2019*). Because of its rarity, with Boulby currently the world's only producer, the global market for polyhalite was previously described as being 'small and insular' (*Humphrey Knight, CRU Group website for 2018*). However, by May 2019 Boulby's operator, ICL UK, had recorded a 30 per cent sales increase, and with global demand growing, a yearly output of 1Mt by 2020 was hoped for (*Teesside Live website*).

But Boulby's unique position changed when Sirius Minerals Plc joined this bonanza. It revealed a polyhalite resource estimated at 2.66 billion tonnes, which will be extracted from its Woodsmith Mine, located a few miles south of Whitby. The resource extends eastwards for at least several miles beneath the North Sea and its complex mineralogy is described by Kemp *et al.* in the journal *Economic Geology* (2016: doi.org/10.2113/econgeo.111.3.719). Given the annual tonnage output already anticipated from Boulby, and the 10 Mt per year planned for Woodsmith's Phase 1 (*CRU Group website, April 2018*), there are some obvious environmental concerns. Sirius Mineral's radical solution is that rather than transporting the mineral across the National Park, they will move it *underground*. Two large access mine shafts are currently under construction, and once production commences it



Cartoon showing the Woodsmith Mine operations, compiled from open-file reports by Sirius Minerals plc (not to scale)

is planned that a conveyor belt running through a 23-mile-long tunnel will transport the mineral outside of the National Park to port at Teesside. There it will be granulated at a materials handling facility, with the majority being shipped to overseas markets.

Ambitious projects like this generally hit snags, with the problem here being to do with finance and risk. According to the *Reuters* article, Sirius Minerals had tried to secure a debt-financing package of £2.3bn from the UK government, which in the light of Britain's decision to leave the European Union would be in line with policies intended to build up the country's mining and manufacturing base. But all too predictably no cash was forthcoming from that quarter, forcing the company to go down the more expensive private financing route and splitting the project into two stages. An initial requirement was for £465m, to be raised by the end of March 2020, for completing the mineshafts and first section of the tunnel. For Phase 2, an additional £1.9bn was estimated for the rest of the tunnel and construction of processing and shipping facilities at Tees Port (*Infrastructure Intelligence News, November 2019*). Unfortunately these funds did not materialise, and by the end of 2019 a slump in share prices had raised the spectre of administration. Such is the potential of the project, however, that in January 2020 Anglo American stepped in to buy the company. Although the price offered (£405m) was only about a third of the original valuation (*Guardian website, 20 January 2020*), the takeover went ahead the following March. The newly-named 'Woodsmith Project' has been delayed by the coronavirus pandemic but is now back on course, with a workforce that had returned to its original levels by August (*Kelley Price: Teesside Live, 30 July 2020*).

Vesuvius VIP victim identified?

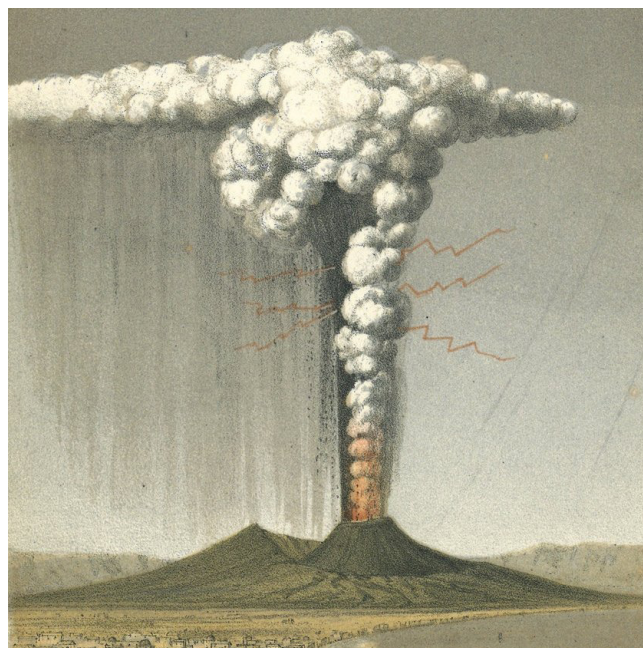
One afternoon in AD 79 the Roman statesman and writer Gaius Plinius Secundus, otherwise known as Pliny the Elder, watched the mounting threat posed by the Mount Vesuvius eruption, which was to claim about 16,000 lives. But rather than following his fellow Romans in flight he organised a small fleet of ships and set off on a rescue mission that was to cost him his life, although it is uncertain whether the 56-year-old came to grief as a result of asphyxiation or a heart attack.

Fast forward then, to the early 1900s when an engineer named Gennaro Matrone discovered roughly 70 skeletons buried together near the shores of Stabiae, a town about 5 km south of Pompeii overwhelmed by ash fall-out and where it is known that Pliny's men were forced to leave him after he collapsed. One of the skeletons suggested a very important person, adorned as it was with a golden triple necklace chain, golden bracelets and a short sword decorated with ivory and seashells. Matrone thought that this could well be the remains of Pliny himself, but following much derision by the scientific community of his day he sold the artefacts and reburied most of the bones.

Except, that is, for the cranium, which Matrone lodged with Rome's Museum of the History of the Art of Medicine. There it remained, mostly forgotten, until it was retrieved in 2017 by Andrea Cionci, an art historian and freelance journalist. Following an appeal for forensic analysis, researchers led by military historian Flavio Russo used modern DNA sequencing technology to test Matrone's original theory in earnest (K. J. Wu: *smithsonianmag.com*, 27 January 2020). Although it may never be possible to identify the skull's original owner conclusively, its DNA and overall shape are compatible with a man possessing some Italian ancestry who likely died in his forties or fifties. Physical anthropologist Luciano Fattore concludes that 'On average, these numbers are compatible with the possibility that the skull belonged to Pliny' (Ariel David, reporting for Haaretz).

Was Pliny's fateful expedition motivated entirely by a need to rescue his countrymen, or did curiosity and a need to investigate also come into it? We know that he was an eminent naturalist and philosopher, who at the time of his death had been putting the finishing touches to one of the world's earliest encyclopaedias. *Naturalis Historia* (Natural History), with 37 books in all, is one of the largest surviving single works of the Roman Empire and its scope was extremely wide: as Pliny put it, 'the natural world, or life'. It is true that many of Pliny's subjects were somewhat far-fetched; including, for example, monsters such as the *Cynocephali* or Dog-Heads, the *Sciapodae* whose single foot could act as a sunshade, and the mouthless *Astomi*, who lived on scents. He nevertheless had the reputation of being meticulous in disclosing his sources, thereby perhaps absolving himself from any suspicion that he found such stories credible. His geological accounts mainly concentrated on gemstones and minerals such as gold and lead, important to the Roman imperial economy, although he was critical of the greed and corruption that often accompanied their extraction (*Wikipedia*).

We might not have known much about Vesuvius' greatest recorded eruption were it not for the work of a witness who happened to be a family member – Pliny the Younger, nephew of the 'Older'. A high-ranking member of the Roman senate, the younger Pliny published his forensic and literary speeches with great care and erudition, and this is shown in his detailed account of the eruption cloud that he witnessed. One passage in particular has inspired artist's impressions down the ages and very accurately records what modern volcanologists now call a Plinian eruption: '...The cloud could best be described as more like an umbrella pine than any other tree, because it rose high up in a kind of trunk and then divided into branches. I imagine that this was because it was thrust up by the initial blast until its power weakened and it was left unsupported and spread out sideways under its own weight...' (Full translation in: Scarth & Tanguy, 'Volcanoes of Europe', 2001, Oxford University Press).



Vesuvius in eruption, by George Poulett Scrope (1822)

EDITORIAL

Greetings from your new Editor

It was just my luck to take on the editorship of *Mercian Geologist* in this year of the Covid-19 pandemic. A true baptism of fire. There was, of course, no meeting of the Editorial Board this year to discuss important issues concerning content and review of submitted papers. Likewise, owing to social distancing restrictions, your hapless new Editor was able to obtain only limited tuition in the technicalities of InDesign, the publication software we employ for the production of *Mercian Geologist*. Thus, all has proceeded rather slowly this year, but would have made almost no progress without the guiding hand of Tony Waltham, the previous editor. I now know just how much hard work he put into editing and formatting the various submissions that are sent to us for consideration.

I am especially grateful to John Carney for continuing to provide us with his excellent Geobrowser, which I have no doubt has wide appeal among our readership.

We published an obituary of Trevor Ford in the 2019 issue of *Mercian Geologist*, but he was such an iconic figure in East Midlands geology that I make no apology for including in this year's number a more complete celebration of his life and work, kindly submitted by Jim Riding and Noel Worley. Otherwise, this year's issue has a strong Quaternary theme.

Finally, with the completion last year of volume 19 of the *Mercian Geologist*, I would just remind readers that we no longer issue indexes of the contents of each completed volume, since this is now accessible through Google search.